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THE SUMMER FOOD PLANTS OF THE GREEN APPLE APHID

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BULLETIN 313

THE SUMMER FOOD PLANTS OF THE GREEN APPLE APHID.[1]

(Aphis pomi)

By Edith M. Patch.

Introduction.

So far as I am aware there is no published indication that the green apple aphid is a migratory species, if by migratory we understand an aphid which passes the fall, winter and early spring on one species of food plant and the summer on a different species of plant. In fact the entire life cycle[2] of this insect has been traced through on apple alone; and it is the common experience of entomologists in different parts of the country to find the green apple aphid on the apple in the summer as well as in the spring and fall. The realization came to me therefore with somewhat of a shock that early in the summer winged forms developing on the apple, fly not only to fresh vigorously growing shoots of apple, but also to a wide range of other vegetation where it establishes colonies which thrive during the summer. Suddenly to find an insect, which one thinks one knows in all of its phases, unconcernedly busy with tricks and manners here-to-fore unsuspected is disconcerting. When, moreover, the insect is discovered to have structural variations wider than it is usual to expect for a single species, the first shock of surprise settles into a stage of perplexity that is not altogether comfortable. Because the career of the green apple aphid is enough to astonish even entomologists inured to aphid vagaries, I have hesitated to publish the results of investigations with *Aphis pomi* for the season of 1922 until viewed through the perspective gained by certain follow-up observations during the season of 1923.

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[1]Papers from the Maine Agricultural Experiment Station: Entomology No. 112.

[2]1916. A. C. Baker and W. F. Turner, Morphology and "Biology of the green apple aphis." Journal of Agricultural Research, v. 5, p. 955-990.

SIMILAR BUT NOT IDENTICAL GREEN OR YELLOW APHIDS.

There are in Maine and, judging from collections submitted to me for determination, in other parts of the country as well, small aphids abundant on weeds, plants in flower gardens and vegetables. That they are only summer residents on such plants is apparent from the fact that the first spring generation (stem-mothers) are never found among them and that they depart in the fall, previous to the deposition of the overwintering egg; but whence they come and whither they go has been tantalizingly mysterious. They vary considerably in size. They may be massed in colonies on the stem, or more or less appressed to the ventral surface of the leaf, or may apparently favor the blossom cluster, especially when in the vigorously growing bud stage. They may be green, in tones from rather vivid to watery pale; or they may be yellow of various tints.

With reference to such aphids, three courses are open to entomologists. They may be described again and again as "new species", each for its separate food plant; they may be massed under that conveniently composite term of *"Aphis gossypii";* or they may be held in collections as undetermined material until the primary or spring food plant is discovered and their life cycle known. Both the first and second courses have been frequently followed. As regards the third course, there is still much to be done; but it has been an immense relief to me to find that the great bulk of such aphids in this part of the country, if given microscopic examination, can be assigned definitely to three species as follows:

1. Cauda "bushy", with approximately 6 hairs on each side....*Aphis pomi*
   Cauda with 2 to 4 lateral hairs.....2
2. Cauda with 3 (sometimes 2) strong hairs on each side near tip of cauda (and in mounted material curved up about tip). Antenna of winged female without sensoria on segment IV .....*Aphis gossypii*
   Cauda with 3 or 4 lateral hairs but not concentrated near tip, not so long as in *gossypii* (and in mounted specimens only the terminal pair curved to touch). Antenna of winged female with sensoria on IV.....*Aphis abbreviata*

Aphis pomi and *Aphis abbreviata* each throws two strong color varieties, one green and one yellow, and is found in all the intergrading blends, while the color range of *Aphis gossypii* is of common comment.

In living material there would be no cause for confusing large sized green *Aphis pomi* on apple with a typical colony of *Aphis gossypii* on cucumbers or of mistaking either for a thriving colony of *Aphis abbreviata* on cultivated nasturtium *(Tropaeolum majus)*. But the small yellowish *Aphis pomi* on its secondary food plants is easily confused with the small yellow individuals of either of the other species. The facts that *Aphis pomi* and *Aphis abbreviata* have a wide range of summer food plants in common, and that their colonies are sometimes intermingled on the same plant, add to the confusion of the situation. Living material of the green apple aphid would never be mistaken for *Aphis rumicis* and related species, but mounted material especially of the wingless forms might easily be confused with other bushy-tailed species. On the other hand although *Aphis gossypii* can be with definiteness separated from members of the *Aphis rumicis* group under the microscope on caudal characters alone, in life the darker individuals of *Aphis gossypii* and certain allies of *Aphis rumicis* might be taken for the same species, especially when feeding in the same colony.

Colonies of small yellow wingless *Aphis abbreviata* and small yellow wingless *Aphis gossypii* feeding near each other on the same squash leaf have much the same appearance, but with the aid of a hand lens either can be distinguished from small yellow summer forms of *Aphis pomi* as follows:

1. Wingless female with cornicles definitely black.....2
   Wingless female with cornicles pale to slightly dusky.....*abbreviata*
2. Wingless female with cauda definitely black.....*pomi*
   Wingless female with cauda concolorous with abdomen.....*gossypii*

Aphis pomi has previously been recognized by that name only on its overwintering or primary food plant; while both *Aphis abbreviata* and *Aphis gossypii* were named from summer-form material and are probably both known by other names on their primary food plant. It seems not too much to hope that an understanding of these three species will make possible the determination of a large percentage of those non-de-script little green or yellow summer aphids that have so long been stumbling blocks to us. The present bulletin is concerned only with *Aphis pomi (spiraecola);* or as it might be put for the benefit of those who will prefer a more conservative interpretation of the situation

than the writer,—with *Aphis pomi* and *Aphis spiraecola*. In this connection reference is made to page 55 for further discussion.

LIFE CYCLE OF THE GREEN APPLE APHID.

In main outline there are no better data on the life cycle of this insect than the summary given by Baker and Turner[3] (p. 991) which is quoted here:

"The life history of *Aphis pomi* may be briefly outlined as follows: The egg is laid upon the tender twigs of the apple, though occasionally it is laid upon the bark of the older twigs. It is light yellow when laid, but later changes to shining black. Development for a few days is very rapid, after which the egg rests for the winter. When the revolution of the embryo is completed in the spring, an increase in temperature will cause the egg to hatch. Before this revolution a high temperature only tends to destroy it. Early in April the egg hatches by a uniform splitting over the insect's head.

"The stem mother is wingless and becomes mature in about 10 days. She produces summer forms, both winged and wingless, with the winged ones predominating. There are 9 to 17 generations of the summer forms at Vienna, Va. After the second generation the wingless forms always outnumber the others, but winged forms may occur in every generation. They become rare toward the end of the season. On the other hand, a wingless line may be carried from the stem mother to the egg. A third form, the intermediate, may occur throughout the summer.

"The wingless sexes begin to appear about the 1st of September. They occur in all generations, from the eleventh to the nineteenth, inclusive, and probably also in the ninth and tenth.

"The summer wingless forms and the oviparous females, which live longer than the males, remain on the trees at Vienna, Va., until the leaves drop, usually about the middle to the last of November.

"Mating commences toward the close of September, one male usually serving more than one female. Both sexes feed. The oviparous female may lay infertile eggs if not reached by a male, and these eggs do not become black. The fertile egg develops to the resting stage before the first heavy frosts; otherwise it may be winterkilled and will not hatch to a stem mother the following spring."

So far north as Maine, of course, we do not get so many generations as in a climate giving a longer summer season and the appearance of the spring winged forms is much later. But in general the foregoing summary covers the situation except that it indicates a "closed cycle" for but one food plant (as the apple)

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[3]Morphology and Biology of the Green Apple Aphis. Journal of Agricultural Research, Vol. V.

whereas the summer forms also accept, besides the apple, a wide range of unrelated food plants to which winged forms migrate in the early summer and from which fall migrants depart late in the season to return to the primary food plant on which the species overwinters. The list of plants acceptable to this insect is probably still far from complete. But the following plants on which *Aphis pomi* has been found feeding in Maine, will indicate a botanic catholicity of taste which will perhaps seem as surprising to others as it has to me.

Overwintering Food Plants.

The primary food plant of an aphid is that plant on which it habitually deposits its overwintering eggs and on which develop at least two spring generations,—the first or stem-mother, and the second or her immediate progeny. The second generation may comprise in certain species, only wingless or only winged individuals or both. The second generation of *Aphis pomi* includes both winged and wingless forms. The wingless ones remain on the primary food plant while the winged ones take flight. It is usually the case that a migratory aphid accepts some tree or woody shrub for the primary host even when living on herbs during the summer. Most aphids are confined to a single genus of plants for primary host purposes, or at least to a few closely related genera; and some are restricted to a single species of plant. Those of the green apple aphid include certain members of the rose family.

Rose Family.

Pyrus Aucuparia Gaertn. European Rowan Tree or Mountain Ash. (52-22) (68-23)[1]
Pyrus Malus Linn. Common Apple. (327-22A) (646-23) (704-23)
Pyrus japonica Thunb. Japan Quince.
Pyrus communis Linn. Common Pear.
Spiraea Van Houttei. (300-22) (320-22) (435-22) (330-22a, b.) (709-23)

Summer Food Plants.

Although it is not always the case, it is not uncommon for a migratory aphid to accept a much broader group of plants for its summer home than for its winter and spring home. As will be

[1] Figures in parenthesis refer to accession numbers of aphids studied in connection with the preparation of this paper.

seen from the following list, the green apple aphid offers an extreme illustration of such a tendency.

WALNUT FAMILY.

Walnut (164-23)

BUCKWHEAT FAMILY.

Polygonum lapathifolium L. (439-23)
Polygonum sachalinense Sacaline. (41-23) (43-23) (44-23) (48-23)
Rumex crispus L. Yellow Dock. (436-23)

GOOSEFOOT FAMILY.

Chenopodium album L. Lamb's quarters, Pigweed. (435-23)

PURSLANE FAMILY.

Portulaca oleracea L. Common Purslane. (219-22 sub. 1a)

CROWFOOT FAMILY.

Ranunculus acris L. Buttercup. (426-23)

MUSTARD FAMILY.

Capsella Bursa-pastoris L. (219-22 sub. 2a)
Nasturtium palustre L. Marsh cress. (245-22)
Raphanus Raphanistrum L. Wild Radish. (227-23) (432-23)

SAXIFRAGE FAMILY.

Philadelphus coronarius L. Syringa or Mock orange. (434-23)
Philadelphus grandiflorus Willd. (105-22) (234-22 sub. 3a)
Ribes sp. (16-22 sub. a, b) (114-22)

ROSE FAMILY.

Amelanchier canadensis (L). Shad Bush. (126-22)
Pyrus Aucuparia L. European Rowan Tree or Mountain Ash. (52-22) (68-23)
Pyrus communis L. Common Pear. (690-23) (698-23)
Pyrus japonica Thunb. Japan quince. (104-22) (200-22 sub. 1a) (437-22) (524-23)
Pyrus Malus L. Common apple. (122-22) (323-22) (327-22) (303-23) (350-23) (579-23) (645-23) (646-23) (704-23)
Spiraea Aruncus L. Goat's Beard. (311-22) (54-23) (179-23)
Spiraea prunifolia Sieb. Bridal Wreath. (530-23)
Spiraea salicifolia L. Meadow-sweet. (164-22) (234-22 sub. 4a, 4b)
Spiraea Van Houttei (7-22 sub. a) (205-22) (330-22 a, b) (435-22) (644-23) (693-23) (697-23) (702-23) (709-23)

PULSE FAMILY.

Pisum sativum L. Common Pea. (175-23)
Trifolium pratense L. Red Clover. (308-22 sub. 1a)

GERANIUM FAMILY.

Impatiens Balsamina L. Garden balsam. (260-22)

STAFF-TREE FAMILY.

Celastrus scandens L. Bitter-sweet. (88-22) (202-22 sub. 3) (206-22) (233-23) (447-23)

BUCKTHORN FAMILY.

Rhamnus cathartica L. Common Buckthorn. (304-23)

VINE FAMILY.

Ampelopsis quinquefolia (441-23)

MALLOW FAMILY.

Malva rotundifolia L. Common mallow. (304-22 sub. 5a, b, c, d, e)

GINSENG FAMILY.

Aralia racemosa L. Spikenard. (195-22) (199-22 sub. 4c, 4d)

PARSLEY FAMILY.

Daucus Carota L. (110-22) (121-22) (342-23) (406-23)

DOGWOOD FAMILY.

Cornus Amomum Mill. Silky Cornel. (128-22)
Cornus sericea L. (128-22) (175-22)
Cornus stolonifera Michx. Red-osier Dogwood. (234-22 sub. 2a, 2b) (46-23)

OLIVE FAMILY.

Forsythia suspensa Vahl. (100-22)
Ligustrum ibota Sieb. (198-22)

DOGBANE FAMILY.

Apocynum androsaemifolium L. Spreading Dogbane. (132-22)

MILKWEED FAMILY.

Asclepias Cornuti Dcne. (263-22) (308-22 sub. 2a, b, c, d) (55-23)

MINT FAMILY.

Galeopsis tetrahit Linn. Common Hemp Nettle. (371-23)

PLANTAIN FAMILY.

Plantago major Linn. Plantain. (290-23) (443-23)

HONEYSUCKLE FAMILY.

Sambucus canadensis L. Common Elder. (187-22)
Viburnum dentatum (L). Arrow-wood. (91-22)
Viburnum Opulus var. *americana* Highbush Cranberry. (89-22) (50-23) (298-23) (581-23)

COMPOSITE FAMILY.

Eupatorium perfoliatum L. Thoroughwort. (163-22)
Eupatorium purpureum L. Joe-Pye Weed. (23-19)
Leontodon autumnalis L. Fall Dandelion. (247-22) (429-23)
Matricaria matricarioides P. Rayless chamomile. (431-23)
Sonchus oleraceus L. Common Sow-thistle. (446-23)
Taraxacum officinale Weber. Common dandelion. (445-23)

METHODS OF STUDY.

The immediate incentive to undertake experimental work with a view to testing the summer habits of the green apple aphid was furnished by what might be called the "migration-poise" of the winged aphids on both apple and Spiraea early in the summer of 1922. The shoots of *Spiraea Van Houttei* on the University Campus which had been very heavily infested all the spring were fast becoming deserted. The young aphids, at a stage when their wing pads indicated that an impending moult would leave them equipped with wings, were creeping off to the underside of the leaves as is customary at such a time. As soon as the moult had occurred and the wings were ready for use these insects were found on the upper side of the leaves poised with that alert aspect which is entirely absent in the same insect when it is settled down for a sap-imbibing meal. At such a time an aphid is bound to intrigue one's curiosity. "Whither away?" is the inevitable question unless the habits of the species are certainly known.

In this case experimental evidence was needed to show whether the aphid on the Spiraea (*Aphis spiraecola* Patch) was, as I have for some time suspected, actually the same as the green apple aphid. I have been unable to find any constant structural differences except in the sex forms; and it is not without precedent to find dimorphism in the egg-producing generation of certain species of aphids.

As experimental evidence as to the identity of *Aphis pomi* and *Aphis spiraecola* the following records may be copied from my notes:

June 21, 1922, 9:30 A. M. Ten newly developed winged *Aphis pomi* collected from apple previous to their flight were placed on a freshly cut sprig of Spiraea in vial under cage. These accepted the Spiraea and established a good colony on that plant. June 30, 2 P. M. the first of their progeny was observed to be mature, an apterous female. (7-22 sub. a).

June 21. A large number of winged *Aphis pomi* from apple were liberated in a cage containly freshly cut shoots of apple and Spiraea. They chose the latter, colonizing that with their progeny. None settled on the apple in this test, perhaps because apple cuttings do not retain their succulent condition. In the open it is known that these forms also accept apple.

September 13. Apterous females of *Aphis pomi* were removed from the ventral side of apple leaves and caged on *Spiraea Van Houttei*. These accepted their new food plant and on October 18 their descendants were observed to comprise the fall sex forms,—apterous males and apterous oviparous females of the same type as these forms when found on apple. Some eggs had already been deposited on the twig.

During the summer several reciprocal tests were attempted by caging migrants of *Aphis spiraecola* from Spiraea on apple cuttings in water. These all failed; but as check experiments of caged migrants of *Aphis pomi* from apple also failed to colonize apple cuttings, it was surmised that the apple cuttings did not retain an inviting degree of vitality. So on July 1, ten winged *Aphis spiraecola* collected from Spiraea were bagged on each of three clean shoots on apple tree. These established colonies on all three shoots, and by July 14 mature wingless forms had developed.

It was originally planned to conduct duplicate transfer tests by caging both apple-grown and Spiraea-grown individuals on the same various plants; but the green apple aphid on apple in 1922 was heavily hit by fungous disease so that it became difficult to secure healthy stock. The Spiraea material was in better condition and the bulk of the transfers were made with migrants from that plant. Cuttings from comparatively few plants will keep in suitable condition to serve an aphid colony through an entire generation. In certain of the tests undertaken even when the migrant settled and started colonies, the food plant fizzled out. Such cases are not recorded in this bulletin as they served only as indica-

tions of what food plants were likely to prove attractive when in normal vigorous growth. These suggestions however, were followed up by field collections and observations.

July 27, 1922 Spiraea-grown migrants just ready for flight were caged over a cutting of spikenard *(Aralia racemosa)*. July 29, 20 migrants were feeding on budded flower spike. August 4, all but two of the original migrants had died but their nymphs were feeding well, crowding the flower-spike. On August 8, five mature apterous females were counted in the colony. On August 16, three nymphs with well developed wing pads were noticed. These probably represented the second spikenard generation, progeny of the first or apterous forms. August 17, the first fully developed winged form was found, (199-22, sub. 4).

August 1, apterous females were taken from *Spiraea Van Houttei* and caged on bitter-sweet, *(Celastrus scandens)*. These accepted the new plant and they and their progeny thrived. August 14, seven of these had matured to apterous adults and one last-instar nymph with wing pads was present, (202-22 sub. 3).

August 7, winged females were taken from *Spiraea Van Houttei* and caged on purslane *(Portulaca oleracea)*. Their colonies did well and by August 19, mature apterous forms had developed, (219-22 sub. 1a).

August 7, winged females were transferred from *Spiraea Van Houttei* to shepherd's purse *(Capsella Bursa-pastoris)*. Their colonies lived through to produce the mature apterous form by August 21, (219-22 sub. 2a).

August 11, winged females were transferred from *Spiraea Van Houttei* and bagged on shoots of red-ozier *(Cornus stolonifera)* out of doors. This material lived and on August 24 their apterous daughters had begun to be matured, (234-22 sub. 2b).

August 11, winged females were transferred from *Spiraea Van Houttei* and bagged on large flowered mock orange *(Philadelphus grandiflorus)*. Their progeny thrived and apterous females had matured by August 29, (234-22 sub. 3a).

August 11, winged females were taken from *Spiraea Van Houttei* and bagged on meadow-sweet *(Spiraea salicifolia)*. These colonies lived and by August 21 mature apterous specimens had been reared on the meadow-sweet (234-22 sub. 4b).

August 31, apterous females were transferred from *Spiraea Van Houttei* and bagged on common mallow *(Malva rotundi-*

folia). The colonies they started lived, showing especial liking for the flower stems. By September 13, mature apterous females had developed. By September 19, a winged female had matured and had settled to feed, (304-22 sub. 52, b, c, d, e).

September 1, apterous females were transferred from *Spiraea Van Houttei* and bagged on red clover *(Trifolium pratense).* These and their young lived and some of the latter had matured by September 18, (308-22 sub. 1a).

September 1, apterous females were taken from *Spiraea Van Houttei* and bagged on milkweed *(Asclepias cornuti).* By September 18, several mature apterous females were secured and September 20 two winged females matured (308-22 sub. 2a, b, c, d).

Aside from the crucial transfer tests, both my assistant and I spent considerable time in the field for the purpose of locating migrants from apple or Spiraea settling on different vegetation and establishing colonies. As winged migrants ready to leave both apple and Spiraea exhibited two marked size variations and as such migrants when settling on their summer food plants were also found in these two size variations, the inference seems fair that a "dwarf variety" is common for the species under consideration, a size difference merely. They left the primary food plant on the same date and from the same colonies but it is not known whether they represented the same or different generations.

Besides the size difference just indicated, this species exhibits so wide a structural variation in cornicle length and antennal characters that except for the background of experimentally bred material, I should not have been able to place the field collections with certainty. An acquaintance with the varietal range once made, however, *Aphis pomi* is an easily recognized species; both in life and properly prepared mounts.

THE QUESTIONS OF SYNONOMY AND VARIABILITY.

Under just how many names the summer progeny of migrants from *Pyrus* and *Spiraea* may be masquerading through the pages of aphid literature is an interesting speculation that does not concern the present bulletin. The grounds for considering the green apple aphid and the green Spiraea aphid the same species, however, should be clearly stated. The green apple aphid when placed on Spiraea colonizes that plant, the progeny developing in a normal way. Conversely the green Spiraea aphid thrives on apple, producing young that grow to maturity. This, of course, is not proof of identity. Neither is the fact that I have not been able to find consistent characters in the viviparous forms (either winged or wingless) to distinguish the apple aphid from the Spiraea aphid either in living material or microscopic preparations. But taken together they partially comprise the reasons why I found it impossible to tell with collections from summer (secondary) food plants whether the progenitors were migrants from apple or Spiraea.

So far as my own collections have gone, I have taken only winged males, and oviparous females with hind tibia thickly studded with sensoria, of *"Aphis spiraecola";* and wingless males of *"Aphis pomi"* together with oviparous females having comparatively slender hind tibia with few sensoria. It is not unprecedented to find both winged and wingless males in the same species of aphid; and in a species variable in the viviparous generations, how much significance the question of more or fewer tibial sensoria would have I do not know. So far as antennal characters are concerned, a glance at Fig. 17 will show that there is more difference between 690-23 and 704-23 (both apple-grown male *"pomi"*) than between 704-23 and 693-23 (Spiraea-grown male *"spiraecola"*).

My own present interpretation of the situation is that we are concerned with one very variable species; that *Spiraea* and not *Pyrus* was the original primary food plant of the species; that the normal cycle is still followed with reference to Spiraea; that *Pyrus* with its succulent succession of summer growth (water sprouts etc.), and its dormant overwintering habit, has proven satisfactory enough to serve as an all year host; and that the species in the sexual generation is dimorphic, the rather degen-

erate forms on the apple (with wingless male) being a modification in the "apple race" in the sexual generation.

Certainly the species is unstable to a marked degree. The occurrence of intermediates[5] or wingless females having antennae like those of winged ones (see Fig. 20, 55-23C) is frequent. Yellow forms with plump bodies like those of females, having antennae and genitalia typical of males (see Fig. 17, 704-23) are found among the sexual individuals on apple.

Although the colonies, both on *Spiraea* and *Pyrus* are for the greater part green, yellow forms are not uncommon on the former plant, the oviparous female being characteristically of that color; and yellow forms are frequently taken on apple (Fig. 21, 299-18). On the summer food plants the species may be either green or yellow.

The great range in size is indicated by the antennal lengths in the figures; and a study of these will show that the size difference is striking even in identical colonies on identical dates.

As regards the variation in the number and distribution of sensoria in the antennae of the winged form attention is called to the following specimens. Fig. 15, 7-22 gives an antenna of one apple-grown individual having 2 sensoria on segment IV and that of another in the same collection having none on IV. Fig. 16, 304-22 sub. 5e shows one antenna and segment III of the other antenna of the same individual, that on one side having four sensoria that on the other having eight. 304-22 sub. 5e has two sensoria on segment IV while 308-22 sub. 2b has three on IV and a basal one on V, and 199-22 sub. 4b (Fig. 15) has no sensoria on IV. The number and arrangement of sensoria on III (whether in a line or scattered) the presence or absence of sensoria on IV and the presence or absence of secondary sensoria on V have all frequently been considered sufficient basis for the erection of new species; and yet these three specimens are experimentally bred progeny of the same species transferred from Spiraea and reared respectively on mallow, clover and spikenard. Fig. 22, 361-22 shows entire antenna of one side (segment IV with four sensoria) and the segment IV of the other antenna of the same individual having no sensoria at all. 437-22 of the same figure

[5]Turner, W. F., and Baker, A. C. 1915. On an occurrence of an intermediate in *Aphis pomi* Degeer. *In* Proc. Ent. Soc. Wash., v. 17, no. 1, p. 42-51.

shows antennae of two different individuals in the same *Pyrus* colony, one having four sensoria on IV and one having none.

Some collections show a relatively longer cornicle on *Pyrus* material. A glance at the following figures will show that this is not a stable distinction. Fig. 15, 7-22 sub. a (daughter of migrant from apple) has a shorter cornicle in comparison with antennal measurements than 199-22 sub. 4c which is descended from Spiraea stock. Compare Fig. 15, 7-22 sub. a (Spiraea-bred daughter of migrant from apple) with the lower 122-22 (apple-bred daughter of migrant from Spiraea) and it will be noticed that in this instance the descendant of the Spiraea migrant has much the longer cornicle in relation to the antenna, these being nearly the same for the two specimens.

ECONOMIC STATUS

The work of the green apple aphid on the apple needs no description either to entomologist or orchardist. The damage it does by stunting the new growth and crumpling the leaves is too well known to require comment.

The knowledge, however, that this species accepts so wide a summer range in one locality as 24 botanic families (and the list is probably far from complete) opens up an appreciation of its possibilities for damage to summer vegetation not hitherto credited to it. A full acquaintance with its summer record will have to wait until we know under what names this species has been masquerading during the summer months.

In Maine, its summer colonies so far have not been observed to be very numerous on especially important commercial vegetation. More than any other aphid with which I am acquainted, this species seems to have a tendency to touch many of its hosts for the duration of but one or two generations. In some cases it remained breeding among clusters of buds for a generation or two; and then instead of scattering to other parts of the plant, took flight to other locations. Although not confined to blossom clusters, it certainly shows a marked preference to them, on many of its food plants.

Its summer dispersal habits lay it open to the possibility of serving as a carrier of plant disease; but it has not received experimental study in this connection.

The bearing of its summer habits on its economic relation with the apple can not yet fully be stated. Does it migrate back again to the apple in the fall; or do the bulk of the fall migrants return, instead, to the *Spiraea* for the overwintering host? If the apple is reinforced in the fall or during the summer from other summer food plants, the apple is obviously worse off than if it has to bear the damage, only, of such colonies as pass the summer on the apple, remaining to deposit the overwintering egg.

If, however, as there seems some reason to suspect, the fall migrants are drawn chiefly to the *Spiraea,* the apple is none the worse for the proximity of infested weeds or other summer food plants; though these on the other hand may become badly infested by spring migrants from the apple.

The tactics of the fall migrants of this species should receive further study before we can understand the full relation of the apple and other food plants with reference to the green apple aphid. Although, from its long association with the apple, it has been looked upon as one of our best known aphids, it has certain habits with which we are far from familiar; and there still remains much to be learned about this species.

Acknowledgments.

I have to thank Dr. A. C. Baker of the U. S. Bureau of Entomology for an examination of my 1922 material of *Aphis pomi;* for certain valuable sidelights thrown on the tri-species problem involved; and for reading this bulletin while in manuscript. Mr. J. T. Potgieter of Zastron, Orange Free State, South Africa made plain to me certain characters of *Aphis gossypii* which had heretofore escaped my attention, thereby clearing up one hazy aspect of the situation. Miss Iva A. Merchant, field assistant during the summer of 1922 under my direction, should be credited with careful and tireless work in connection with the field collections and also for help in the transfer tests that made this bulletin possible.

EXPLANATIONS OF FIGURES.

The drawings are camera lucida sketches from microscopic preparations. They are all drawn to the same scale for the purpose of convenient comparison. Antenna, cornicle, and in some cases hind tibia are the details given; and these are all from fully matured individuals. The antennae of the wingless females can be distinguished as having no sensoria on the third segment. As they are from total mounts and not dissected specimens some slight apparent variation may be due to faulty perspective but as all mounts were made thin enough to use under a 1/6 objective, this item will not seriously damage the evidence the sketches present.

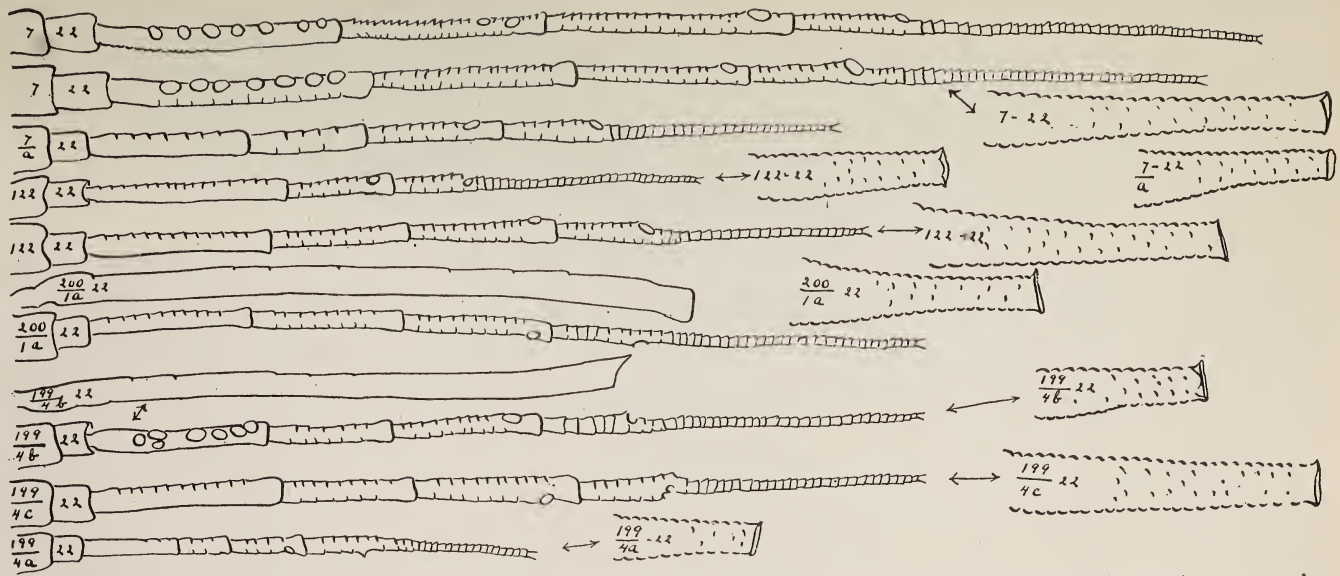

FIG. 15. Details of bred material. 7-22, two migrants taken from apple, June 21 and caged over cuttings of Spiraea. 7-22 sub. a, wingless female, daughter of migrant from apple, reaching maturity on Spiraea on June 30. 122-22, two wingless females developing on apple previous to July 14, being daughters of winged migrants taken from Spiraea and caged on apple shoot, July 1. 200-22 sub 1a, wingless female reared on Japan quince and mounted Aug. 7. This is a daughter of a winged female taken from apple July 28. 199-22 sub 4, spikenard-bred descendants of migrants from Spiraea; a, wingless female developed Aug. 8; b, winged female mounted Aug. 17; c, wingless female mounted Aug. 19.

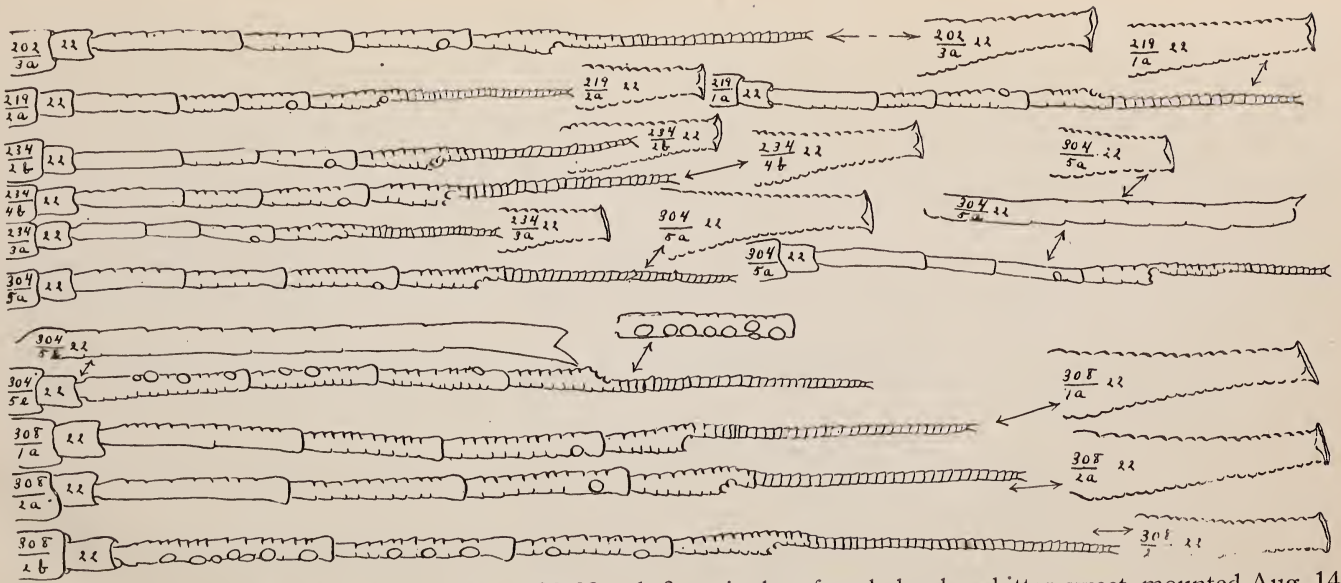

FIG. 16. Details of bred material. 202-22 sub 3a, wingless female bred on bitter-sweet, mounted Aug. 14, daughter of wingless female transferred from Spiraea, Aug. 1. 219-22 sub. 1a, wingless female reared on purslane; sub. 2a, wingless female reared on shepherd's purse; both daughters of winged female taken from Spiraea, Aug. 7. 234-22 sub. 2b, wingless female reared on red-ozier; sub. 4b, wingless female reared on meadow-sweet; sub. 3a, wingless female reared on mock orange; all daughters of winged females taken from Spiraea Van Houttei, Aug. 11. 304-22 sub. 5a, two apterous females and sub. 5e, winged female, all reared on common mallow and descendants of winged females taken from Spiraea, Aug. 31. 308-22 sub. 1a, wingless female reared on clover, sub. 2a, wingless and sub. 2b, winged females reared on milkweed, all descendants of wingless females taken from Spiraea, Sept. 1.

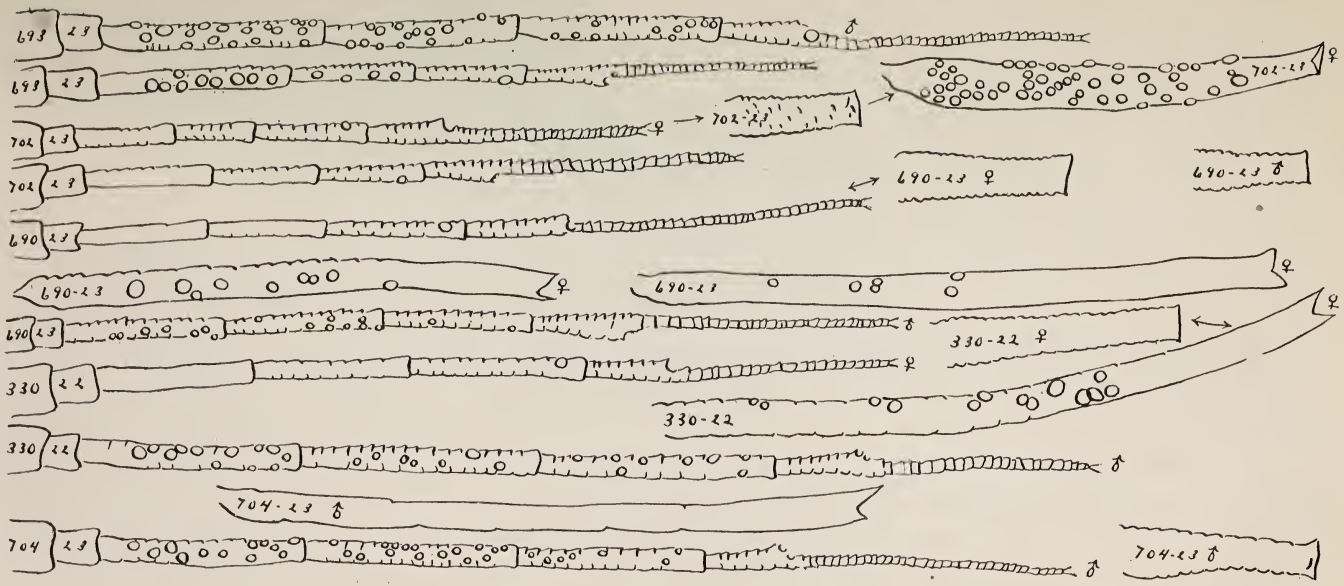

Fig. 17. 693-23, winged male developing on Spiraea and winged viviparous female in same collection. 702-23, antenna, cornicle and hind tibia of oviparous female on Spiraea and antenna of wingless viviparous female from same collection. 690-23, oviparous females (with hind tibiae of two individuals) and wingless male which developed on apple. 330-22, oviparous female and wingless male developing on Spiraea in October as descendants from wingless females transferred from apple to Spiraea in September. 704-23, plump yellow wingless males on apple, quite different from the usual scrawny green ones. For further discussion of Fig. 17, see pages 56, 57.

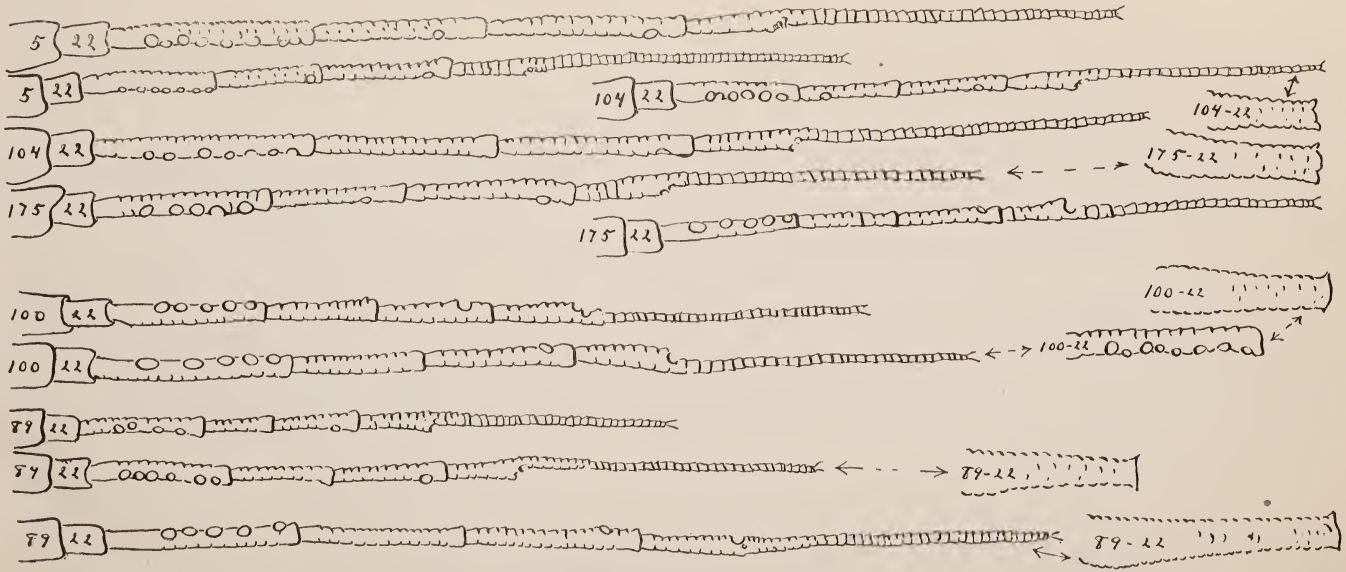

FIG. 18. To indicate range of size of winged females in identical collections, those bearing the same number being from same colony on same plant at same date. 5-22 from Spiraea, June 20. 104-22 from Japan quince, July 11. 175-22 from dogwood(*Cornus*), July 22. 100-22 from Forsythia, July 11. 89-22 from highbush cranberry (*Viburnum*), July 11. See also Fig. 19. 187-22 from common elder, July 25; and Fig. 20, 437-22 from Japan quince, Oct. 19.

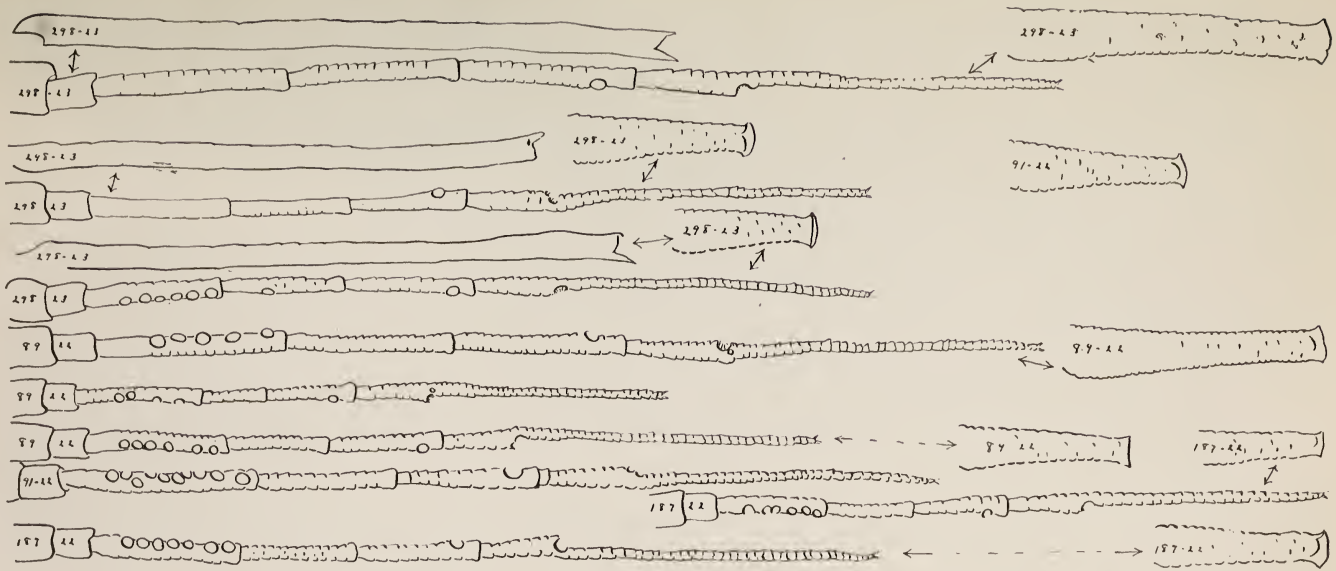

Fig. 19. Indicating variation of this species on plants of the Honeysuckle Family. 298-23 from highbush cranberry *(Viburnum opulus),* July 26. Notice range of size in two wingless females of same colony. 89-22 from *Viburnum opulus,* July 11, gives similar range of winged females. 91-22 from *Viburnum dentatum,* July 11. 187-22 from common elder, July 25.

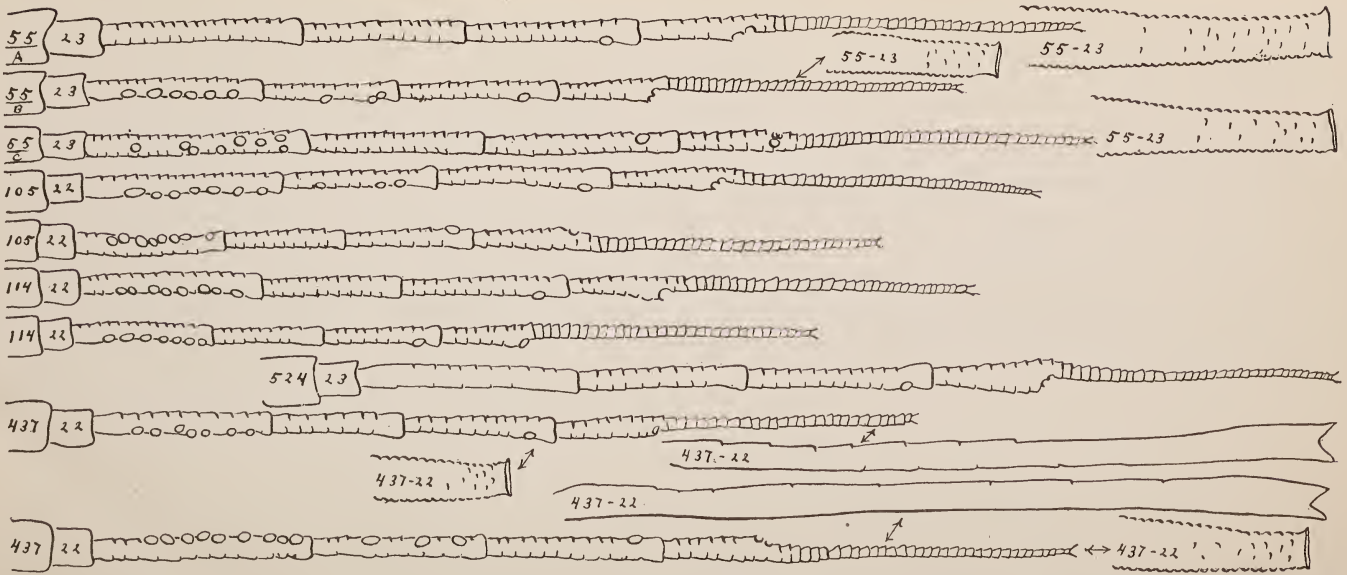

FIG. 20. 55-23 specimens from heavy infestation of milkweed, crumpling terminal leaves, July 5, the third specimen (C) being an "intermediate" or a wingless female having the antennal characters of a winged female. 105-22 from mock orange, July 11. 114-22 from gooseberry, July 13 winged forms with colony of young. 524-23 Japan quince, Aug. 27. 437-22 from Japan quince, Oct. 14.

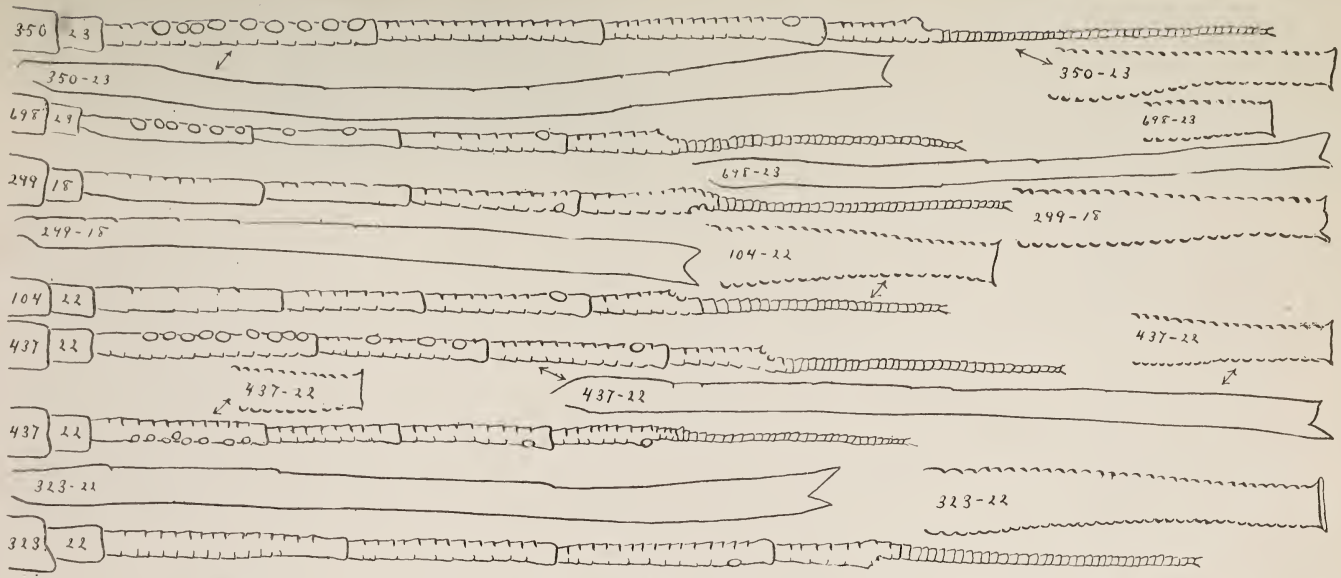

FIG. 21. Details of specimens from *Pyrus*. 350-23 from apple, July 31. 698-23 from apple, Oct. 10. 299-18 yellow "variety" from apple, July 31, Ontario, N. Y. 104-22 from Japan quince, July 11. 437-22 from Japan quince, Oct. 19. 323-22 from apple, Sept. 11. See also Fig. 15, 7-22, 122-22, and 200-22 sub. 1a; Fig. 17, 690-23, 330-22, 704-23; Fig. 18, 104-22; Fig. 20, 524-23, 437-22; and Fig. 22, 579-23, 437-22.

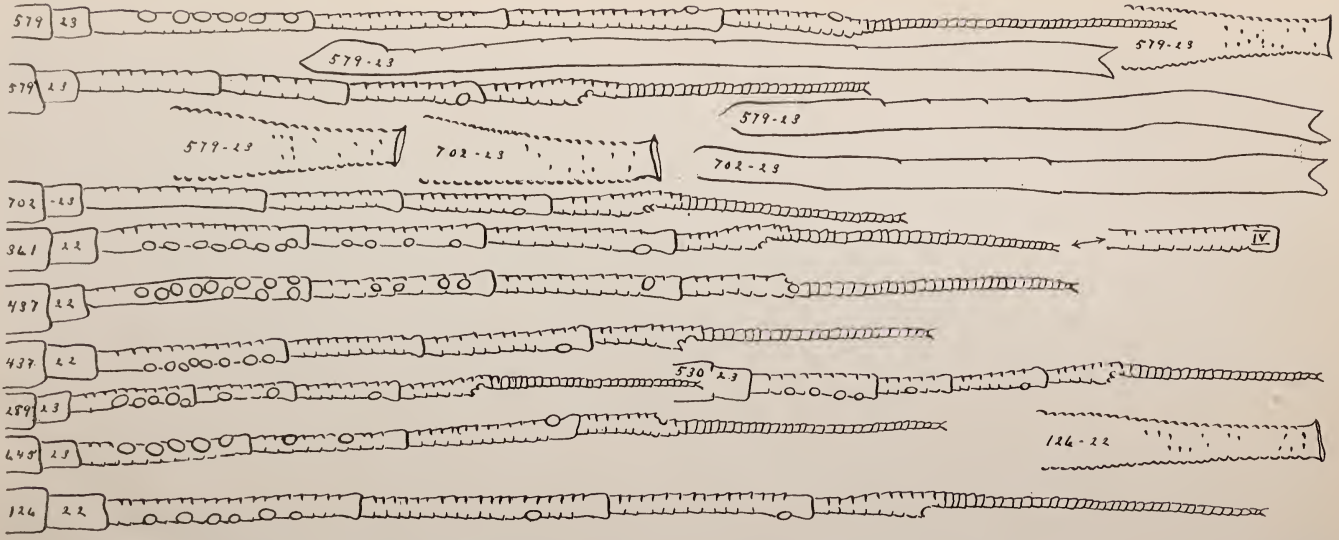

FIG. 22. 579-23, winged and wingless females on newly growing apple leaves, Aug. 30. 702-23, green wingless female on Spiraea, Oct. 13, drawn for comparison with 579-23, notice that antennae, cornicles and tibiae of the two wingless females are nearly identical in size. 361-22, winged female on Spiraea, Sept. 20, with right antenna having four sensoria on segment IV and left with no sensoria on IV. 437-22, two individuals from Japan quince Oct. 19, one with four sensoria on IV, one with none. 289-23, *Spiraea Van Houttei,* July 26. 530-23, *Spiraea prunifolia,* Aug. 30. 645-23, apple, Oct. 3. 126-22, Juneberry, July 15.